SCRIPT TO ACCOMPANY GLFLI AQUATIC BIOLOGY POWER POINT PRESENTATION

Slide No.

1. Great Lakes Fisheries Leadership Institute: AQUATIC BIOLOGY

2. First, A few words about water –

3. **WATER** becomes the most dense at 4 degrees centigrade (39^{o}F) – that's why ice floats and the warmest water is at the bottoms of frozen lakes.

4. **WATER TEMPERATURE** is an important water quality parameter which controls chemical reaction rates and the metabolism of cold-blooded organisms. It also controls the solubility rate of dissolved gases, including oxygen.

   * Most fish require 3-5 ppm minimum of dissolved oxygen.

5. **pH** measures the acid-base condition of water. It is on a logarithmic scale, meaning each number has 10 times the concentration of the previous number. 7 is neutral, with a value of 1 being most acidic and a value of 14 being most basic. pH can control the availability of nutrients to plants and the toxicity of harmful substances.

6. **TRANSPARENCY** is measured with a Secchi disk to find the depth of sunlight penetration. The maximum depth of light penetration limits the size of the zone in which biological production occurs.

7. Water expands another 1/11th of its volume when it freezes. This can gradually heave dock posts from their foundations and cause objects containing water to fracture.

8. Water can transport huge amounts of energy as heat. Water that reaches O^{o} C or 32^{o} F will not freeze until it loses another 80 calories of heat per gram. That means water in a stream or lake can reach freezing temperature but remain a liquid if motion imparts energy to the water. When water reaches boiling temperature, it must absorb

another 540 calories of heat per gram to vaporize. That's why steam transports so much energy.

9. Lake effect is the ability of a large water body to affect weather over the surrounding land. This can delay warming in the spring and delay frost in autumn. It also causes lake-effect snowfall.

10. **WATER SOURCES** - Surface water and ground water provide water to lakes and streams. Surface water is precipitation runoff. Its temperature varies with air and ground surface temperatures. Surface water can transport relatively insoluble nutrients, such as phosphorus, when they attach to clay particles.

11. Surface water also can transport contaminants like pesticides, road salt and industrial or agricultural wastes.

12. Ground water, coming from aquifers below the Earth's surface, is very uniform in temperature – about 52-55^{o} F, becoming more uniform as the depth increases.

13. Ground water often transports highly soluble nutrients, such as nitrates. It comes from the ground devoid of oxygen and is usually a source of relatively clean water.

14. **THE AQUATIC ECOSYSTEM**

15. An ecosystem can be defined as the community of living organisms and their non-living environment. Here are a few groups of organisms important in an aquatic ecosystem.

16. **Algae** fall into two categories. Phytoplankton are single-celled, free-floating plants. The presence of these is why water often looks green, or sometimes yellow-brown. Attached algae include the filamentous green species that cling to rocks and logs. Other filamentous types can appear as floating mats.

17. **Macrophytes** are larger green plants, usually with distinctive leaves and stems, and usually rooted in the bottom.

18. **Zooplankton** are the tiny, free-floating grazers that feed on planktonic algae and are often called water fleas. Many of these are tiny crustaceans, related to crayfish. Some large zooplankters, like ***Leptodora*** and ***Bythotrephes***, prey on other zooplankton.

19. **Macroinvertebrates** are larger than zooplankton, and usually live on the bottom or attached to other objects. These animals without backbones include insects, worms, shellfish, sponges, bryozoans and several other groups.

20. **Fish** are the most well-known members of the aquatic community but they can't exist without the other community members that live at lower levels in the chain of life.

21. The ecosystem includes non-living components that are vital – water, minerals and nutrients, and sunlight. These provide the energy and materials that support life.

22. The living parts of an ecosystem are called the biotic portion; non-living parts are called abiotic. Energy and matter constantly cycle between the living and non-living parts.

23. Green plants, both phytoplankton and macrophytes, combine nutrients, water and energy from the sun to create protein and carbohydrates, while releasing oxygen. This process is called **primary production**.

24. The amount of primary production occurring in a given area determines the mass of higher-level organisms that can be supported in that area. This can be illustrated by a food pyramid, or pyramid of biomass, in which each block is called a trophic level.

25. The noted ecologist Odum says that the food to growth efficiency rate from one trophic level to the next higher one is about 10 percent. In other words, 10 pounds of food produces about one pound of body weight. ***(Click here)*** If the pyramid has a one-pound walleye at the top, how many pounds of forage fish were needed to produce it? How many pounds of zooplankton? How many pounds of algae?

26. Populations of sport and commercial fishes depend upon all levels of the aquatic ecosystem. Plankton, benthos and forage fish all contribute to the growth and survival of important fish species.

27. LIVING IN THE AQUATIC ECOSYSTEM

28. **Plankton** are microscopic plants and animals which depend upon water currents for most of their movement.

29. Certain species of phytoplankton, like green algae and diatoms, are favored foods of other aquatic organisms. These primary producers are very important to the aquatic food web.

30. Other species of phytoplankton, such as blue-green algae, produce noxious tastes and odors, and can generate toxic waste products. ***Microcystis*** and ***Anabaena*** are examples of these.

31. **Zooplankton**, the microscopic animals which graze on planktonic algae, include several important groups.

32. **Rotifers** are very small and appear early in the year, providing important food to newly hatched fish. **Copepods** and **cladocerans** are larger and become very abundant during summer, providing a rich food source for plankton feeders.

33. Plankton abundance follows a seasonal cycle with periods of both high abundance and low abundance. In early summer, rising temperatures, lengthening days and nutrient inflow from surrounding land bring plankton levels up.

34. By autumn, zooplankton have grazed down the algae and much of the nutrient supply has been absorbed by primary producers. These factors combined with falling temperatures and shorter days bring plankton levels down.

35. Winter often brings a second but smaller plankton peak as phytoplankton species shift toward diatoms and other coldwater species.

36. As the winter plankton community is grazed down, spring begins the cycle anew as nutrients wash in from land areas, temperatures rise, and daylight increases.

37. All young fish are dependent upon plankton as their first food after absorbing their yolk sacs. Some fish species feed on plankton throughout their entire lives.

38. Tiny zooplankton like rotifers provide food during the critical period when larval fish shift from yolk sac nutrition to feeding on external food. This is known as a “critical period.”

39. If plankton blooms do not occur at critical times when food is needed, these tiny young fish may perish.

40. Both phytoplankton and zooplankton serve as the food base which support forage fish, sending energy and nutrients further up the food pyramid.

41. **BENTHOS** is a term that includes all the organisms living on the bottom of a lake or stream.

42. Many diverse groups of organisms are included in the benthos. These organisms display many different body styles and behaviors, and are very widely distributed, due to a wide range of feeding requirements, body and behavior adaptations, and reproductive modes.

43. Benthos are more affected by environmental stresses and catastrophes than plankton and fish because they are less mobile.

44. Benthos display a wide range of physical adaptations that increase their abilities to survive. These include flattened bodies, which assist in hiding in cracks and crevices;

45. Suckers and hooked claws for clinging to objects and climbing;

46. Ballast – heavy shells provide stability in moving water and give protection from predators;

47. Gills and hemoglobin increase the ability to capture oxygen from low-oxygen environments.

48. Many groups of benthos also have behavior characteristics that boost their chances to survive. These include hiding in burrows or vegetation, attaching to surfaces, and avoiding currents.

49. Some of the important groups of benthic organisms in Great Lakes ecosystems include insect nymphs and larvae;

50. Small crustaceans, including scuds and crayfish;

51. And mollusks, such as clams and mussels.

52. **FORAGE FISH** are critical to supporting Great Lakes fisheries. This group includes any fish species that can be preyed upon by other fishes.

53. Most of the Great Lakes' large sport and commercial fish species rely upon forage fish as a food base. Forage fish represent a concentrated source of proteins and fats.

54. Most young predatory fish feed on plankton and sometimes benthos during their first few weeks of active feeding, then switch to forage fish.

55. Forage fish offer a way to transfer energy and nutrients from tiny plankton to large fish species.

56. Now let's cover a few more terms that will help us discuss the organisms in the aquatic ecosystem.

57. A **species** is a group of organisms that interbreed with each other and produce fertile offspring that have the same characteristics as their parents. They rarely can interbreed with other such groups and produce fertile offspring that are identical to both parents.

58. **Populations** are groups of species that are isolated from the same species in other lakes. Lake Michigan and Lake Huron have different

and separated yellow perch populations, but all of the yellow perch are the same species.

59. Within a population in a given lake, some groups of a species may spawn together and stay somewhat separated from other groups within the lake.

60. These are called stocks. Some examples of fish stocks include the Maumee River walleye stock, which exhibits certain different behaviors from Lake Erie's reef-spawning stock. Likewise, Lake Ontario's Bay of Quinte's lake trout stock can physically mix with lake trout from the western part of the lake, but they maintain a certain degree of separation.

61. A Great Lake will have, let's say, a walleye population, a black crappie population and an alewife population, but not a general fish population. All of these different populations make up a fish community.

62. A **community** is defined as all the populations occupying a common habitat and interacting with each other.

63. The community include populations of all organisms – fish, benthos, plants, plankton, bacteria and others.

64. We sometimes speak in terms of individual communities, such as a lake's fish community (made up of several fish populations), the plant community, the invertebrate community and others.

65. All of the individual communities combine into the lakes aquatic community.

66. All aquatic communities are affected by the environment's physical factors, including nutrients, temperature, oxygen, and atmospheric conditions.

67. **NUTRIENTS** are the chemical substances needed to sustain life. The nutrient which is in the shortest supply will limit the extent of biological productivity. This is called a system's limiting factor. In

freshwater, productivity is usually limited by the supply of **phosphorus**.

68. Lakes with low levels of nutrients, low productivity, and usually with clear water are called **oligotrophic** lakes. Lake Superior is an example.

69. Lakes with moderate levels of nutrients and productivity are called **mesotrophic**.

70. Human activities have increased soluble phosphorus levels in many waters, which increases biological production rates. This extra phosphorus comes primarily from agricultural runoff…

71. …And sewage effluents.

72. Lakes with high nutrient levels and high productivity are called **eutrophic** lakes. Western Lake Erie and Green Bay are examples.

73. Although these lakes become more productive and capable of supporting larger fish communities, the water in them becomes turbid, often with excessive algae blooms.

74. Progress is being made in reducing nutrient enrichment. Sewage treatment plants have become more efficient, and agriculturists are employing conservation tillage and filter strips on streams to reduce phosphorus runoff. But some water bodies are still troubled by excessive nutrients.

75. **TEMPERATURE** has an important controlling effect on an ecosystem. Van t'Hoff's Law says that for every 10^{o} Celsius increase in temperature, the speed of a chemical reaction doubles…

76. …And for each 10^{o} Celsius decrease in temperature, the reaction rate is reduced by half.

77. This physical law governs the metabolic rates of all cold-blooded organisms, whether they are bacteria, plankton, benthos, plants or fish.

78. This brings us to a dilemma in the oxygen supply in water. Water can hold more dissolved oxygen and other gasses as the temperature decreases.

79. Conversely, as the temperature of water goes up, it can hold less dissolved oxygen and other gasses.

80. Unfortunately, higher temperatures increase organisms' oxygen needs while the actual supply of dissolved oxygen is decreasing.

81. That helps explain why low oxygen stress is usually seen in hot weather, when the metabolic oxygen demand is high but the supply is relatively low.

82. Another effect of temperature is when deep lakes stratify, forming thermal layers. Most materials shrink or expand as temperature goes up or down. Water molecules move apart at high temperatures and move together at low temperatures.

83. This causes cold water to be more dense, and hence heavier, than warm water. A cup of cold water actually contains more molecules than a cup of warm water; hence the cup of cold water is slightly heavier than the warm cup.

84. The surface of a lake is a very important source of dissolved oxygen, as oxygen molecules diffuse through the interface into the water just below the surface. As brisk winds blow across a lake, the water circulates, mixing it from top to bottom.

85. In summer, bright sun warms the upper part of a lake, making the water lighter than in the colder, heavier water below it. Now a warm layer sits atop a cold layer of water.

86. This effect is called **thermal stratification**. A narrow zone in which the temperature changes rapidly, called a **thermocline**, separates the warm **epilimnion**, or upper layer, from the cold **hypolimnion**, or bottom layer.

87. As wind circulates water within the warm upper layer, it is too light to dislodge the heavy, cold layer. The hypolimnion cannot be recharged

with oxygen from the surface. And light penetration is often insufficient to provide oxygen from photosynthesis.

88. The hypolimnion does not circulate back to the surface until fall turnover, when cool nights chill the warm surface layer, and it becomes about the same temperature as the bottom layer.

89. As the lake reaches a uniform temperature, it can circulate from top to bottom again.

90. As dead plankton, plants and other organic matter settles to the bottom of a lake, they are decomposed by bacteria, a process which consumes oxygen.

91. If the hypolimnion is a very deep or thick layer, it can provide a large reservoir of oxygen through the summer that supports both decomposition and higher aquatic life.

92. If the hypolimnion is a relatively thin layer, decomposition may deplete the oxygen supply. This condition is called **anoxia**. The portion of the hypolimnion that has become devoid of oxygen is commonly called a "dead zone." This condition persists until fall turnover allows the lake water to mix from top to bottom again.

93. To sum it up, a healthy stable lake requires diverse plant and animal communities, adequate, year-round oxygen from top to bottom, and a protected watershed.

END

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